VLBA Test Memo #63

Azimuth Drive Wheels

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I. Introduction

The Brewster antenna suffered an azimuth drive axle failure in October 1999. The failure resulted in almost three weeks of downtime. The axle was part of a new design meant to eliminate bearing failures.[i] The axle failed in fatigue, at the point where it shoulders down for the outboard bearing.

II. Cause

The axle was made of hot rolled 4140 alloy steel in the as-rolled state. Normal operation of the antenna imposed loads on the axle that exceeded the fatigue limit of the steel. (Fatigue limit is the stress below which a steel part can be expected to last indefinitely.) A very small radius at the root of the shoulder exacerbated the problem.

III. Current State of Affairs

We need another assembly for installation in St. Croix in January, 2000. Target ship date is December 20th. This and all future axles will be made of heat treated 4340 steel, which has a fatigue limit in excess of the stresses imposed in normal antenna operation. See Appendix A for an inventory of parts on hand.

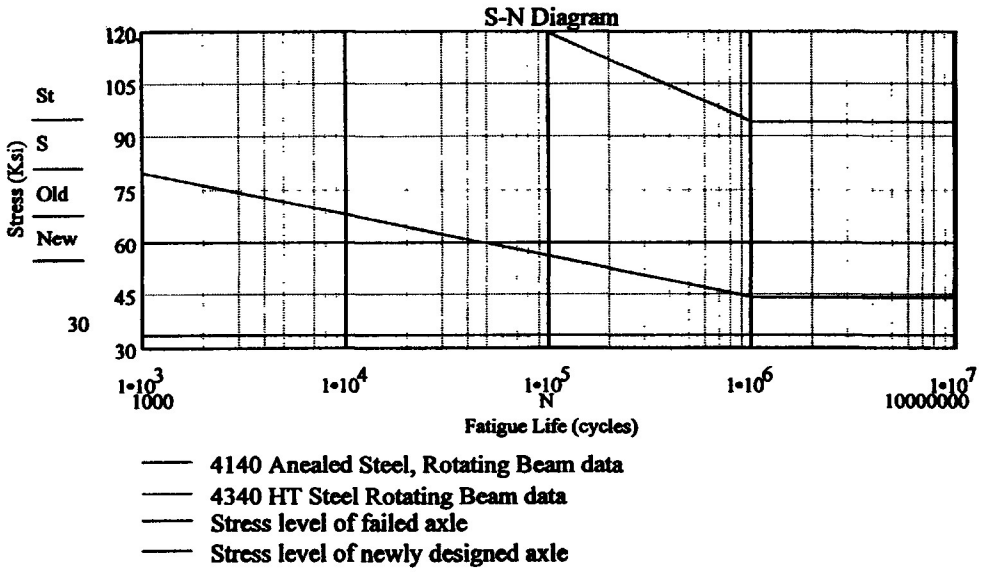
IV. Long Range Plans

a) Brewster

A new assembly was designed, manufactured, and installed on emergency basis to bring Brewster back on line. The new axle has a larger diameter at the critical shoulder. The root radius was carefully controlled to minimize stress concentration. The axle used was the same material as the one that failed, as heat treating would have delayed the repair by several weeks.

The statistical nature of fatigue failure makes it impossible to predict the life of the new shaft at Brewster with certainty.[ii] But, a reasonable life expectancy can be determined using the facts at hand. We know the original shaft lasted 12 months prior to failure. We also know the critical diameter went from 5.51 to 6.30 inches and the fillet radius went from 0.03 to 0.10 inches. Assuming the antenna rotates about 50,000 cycles per year, we can use the S-N Diagram below to put the effective stress at 60 Kips. For the original shaft, the stress concentration was that corresponding to D/d = 1.3 and r/d = 0.006, which is in excess of 3.0. So, the nominal stress on the shaft was 60000/3 = 20 Kips. Increasing the diameter reduced this stress. Bending stress for a round shaft is a function of d^3, so the nominal stress for the new shaft should be $20*5.51^3/6.30^3 = 13.4$ Kips. The stress concentration expected for the new shaft corresponds to d/D = 0.91 and r/d = .016, something less than 2.5. The new effective stress is therefore 33.6 Kips, which is below

the endurance limit for the shaft. A similar calculation starting at 10000 cycles per year yields an effective stress of 45 Kips, which should last the life of the project.



The analysis above, as well as a more extensive analysis performed by Jon Thunborg, indicates that the new axle at Brewster can be left in service with a high level of confidence.

b) Elsewhere

The original RSi assemblies will continue failing at the rate of one or two a year for the next several years. St. Croix needs the next replacement, scheduled for January 2000. Hancock is likely to need replacement soon.

We own two spare wheels. Catastrophic failure of an idler assembly is thought to be unlikely. With these facts in mind, I suggest the following plan:

1) Keep one drive assembly, fully assembled, on hand at all times.
2) Keep one full complement of parts in the warehouse.
3) When a replacement is scheduled, assemble the warehouse parts and replenish warehouse stock.

(Due to the annual year-end budget crunch, we will delay ordering additional parts until January, 2000.)

Appendix A: Current Inventory

Item	Req'd/Ass'y	On Hand	On Order	Machined
Shafts	1	0	2	0
Outboard Bearings	1	1	0	NA
Outboard Bearing LN & LW	1	1	0	NA
Inboard Bearings	1	1	0	NA
Inboard Bearing LN & LW	1	2	0	NA
Pillowblocks	2	4	0	1 needs sleeves
Wheels...	1			
...RBC		1	0	1
...Ringfeder		1	0	1
Couplings...	1			
...RBC		1	0	NA
...Ringfeder		1 set	0	NA
Bolts for RBC Cplg.	12	0	26	NA
Cover plate # 27	3	5	0	5
Cover plate # 28	1	2	0	rework
Seal #10	2	3	0	NA
Seal #11	1	2	0	NA
Seal #12	1	1	0	NA
Gear Hubs	1	3	0	turn length
Gear Flanges	1	3	0	NA
Accessory Kits	1	1	0	NA
Keys	1	1	3	1
Pillowblock Shim packs	1	1	0	1
Misc. hardware	1	1	0	NA

[i] VLBA Test Memo #54, *Investigation of VLBA Azimuth Wheel Bearing Failures*, J. E. Thunborg, July, 97

[ii] *Mechanical Engineering Design*, 3rd Ed. J. E. Shigley. See Chapter 5 and table A-25.